ENERGY EFFICIENCY/RENEWABLE ENERGY IMPACT IN THE TEXAS EMISSIONS REDUCTION PLAN (TERP)

VOLUME I—SUMMARY REPORT

Annual Report to the
Texas Commission on Environmental Quality
January 2010-December 2010

Jeff Haberl, Ph.D., P.E., Bahman Yazdani, P.E.,
Charles Culp, Ph.D., P.E.Cynthia Lewis, Zi Liu, Ph.D.,
Juan-Carlos Baltazar-Cervantes, Ph.D., Jaya Mukhopadhyay, Don Gilman, P.E.,
Larry Degelman, P.E., Kathy McKelvey, David Claridge, Ph.D., P.E.

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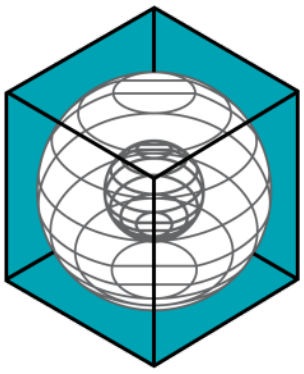

ENERGY SYSTEMS LABORATORY

Texas Engineering Experiment Station
Texas A&M University System

ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System
3581 TAMU
College Station, Texas 77843-3581

December 22, 2011

Chairman Bryan W. Shaw
Texas Commission on Environmental Quality
P. O. Box 13087
Austin, TX 78711-3087

Dear Chairman Shaw:

The Energy Systems Laboratory (Laboratory) at the Texas Engineering Experiment Station of the Texas A&M University System is pleased to provide its ninth annual report, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)," as required under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002 (Senate Bill 5, 77R as amended 78 R & 78S).

The Laboratory is required to annually report the energy savings from statewide adoption of the Texas Building Energy Performance Standards in Senate Bill 5 (SB 5), as amended, and the relative impact of proposed local energy code amendments in the Texas non-attainment and near-non-attainment counties as part of the Texas Emissions Reduction Plan (TERP).

Please contact me at (979) 845-1280 should you or any of the TCEQ staff have any questions concerning this report or any of the work presently being done to quantify emissions reduction from energy efficiency and renewable energy measures as a result of the TERP implementation.

Sincerely,

David E. Claridge, Ph.D., P.E.
Director

Enclosure

cc: Commissioner Carlos Rubinstein
Commissioner Buddy Garcia
Executive Director Mark R. Vickery, P.G.

Disclaimer

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VOLUME I – SUMMARY REPORT

Energy Efficiency/Renewable Energy Impact In The Texas Emissions Reduction Plan

Executive Summary

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of The Texas A&M University System, in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002, submits its ninth annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (TERP) to the Texas Commission on Environmental Quality.

The report is organized in three volumes.

- Volume I – Summary Report – provides an executive summary and overview;
- Volume II – Technical Report – provides a detailed report of activities, methodologies and findings;
- Volume III – Technical Appendix – contains detailed data from simulations for each of the counties included in the analysis.

Accomplishments:

1. Energy Code Amendments

The Laboratory was requested by several Councils of Governments (COGs) and municipalities to analyze the stringency of several proposed residential and commercial energy code amendments, including the IECC and the ASHRAE Standards. Results of the analysis are included in this Volume II-Technical Report.

2. Technical Assistance

The Laboratory provided technical assistance to the TCEQ, PUCT, SECO, ERCOT, and several political subdivisions, as well as stakeholders participating in improving the compliance of the Texas Building Energy Performance Standards (TBEPS). The Laboratory also worked closely with the TCEQ to refine the integrated NOx emissions reduction calculation procedures that provide the TCEQ with a standardized, creditable NOx emissions reduction from energy efficiency and renewable energy (EE/RE) programs, which are acceptable to the US EPA. These activities have improved the accuracy of the creditable NOx emissions reduction from EE/RE initiatives contained in the TERP and have assisted the TCEQ, local governments, and the building industry with effective, standardized implementation and reporting.

3. NOx Emissions Reduction

Under the TERP legislation, the Laboratory must determine the energy savings from energy code adoption and, when applicable, from more stringent local codes or above-code performance ratings, and must report these reductions annually to the TCEQ.

Figure 1 shows the cumulative NOx emissions reduction through 2020 for the electricity and natural gas savings from the various EE/RE programs.

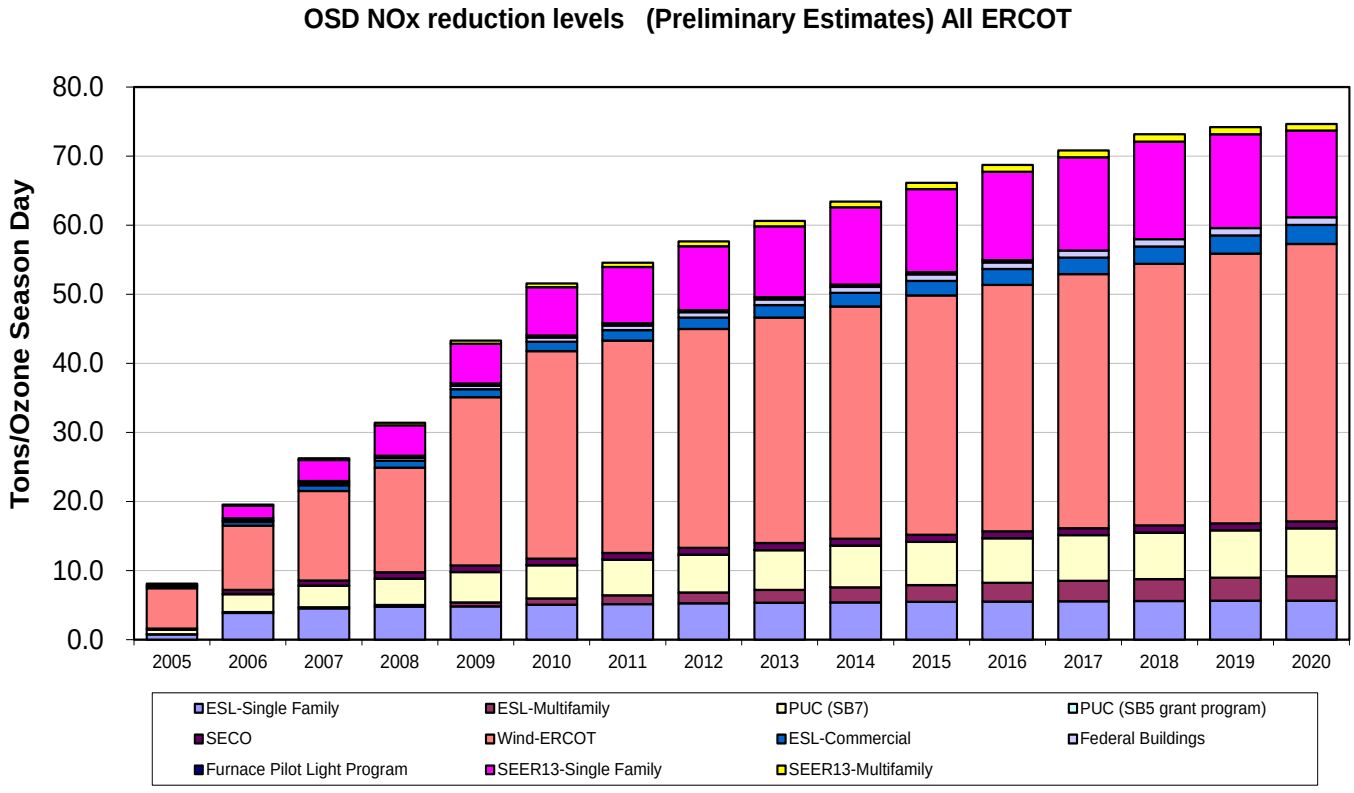

Figure 1: OSD NOx Emissions Reduction Projections through 2020

In 2010, the total NOx emissions reduction from all programs is 15,327 tons-NOx/year which is broken down by the following:

- The cumulative annual NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,189 tons-NOx/year (7.8% of the total NOx savings);
- Savings from retrofits to Federal buildings is 193 tons-NOx/year (1.3%);
- Savings from furnace pilot light retrofits is 117 tons-NOx/year (0.8%);
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 1,637 tons-NOx/year (10.7%);
- Savings from SECO's Senate Bill 5 program is 349 tons-NOx/year (2.3%);
- Electricity savings from green power purchases (wind) is 10,957 tons-NOx/year (71.5%); and
- Savings from residential air conditioner retrofits is 884 tons-NOx/year (5.8%).

In addition, the following OSD NOx reductions are expected for 2010:

- The OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 6.56 tons-NOx/day (16.1%);
- Savings from retrofits to Federal buildings is 0.51 tons-NOx/day (1.3%);
- Savings from furnace pilot light retrofits is 0.32 tons-NOx/day (0.8%);
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 4.39 tons-NOx/day (10.8%);
- Savings from SECO's Senate Bill 5 program is 0.95 tons-NOx/day (2.3%);
- Electricity savings from green power purchases (wind) are 21.79 tons-NOx/day (53.5%); and
- Savings from residential air conditioner retrofits are 6.19 tons-NOx/day (15.2%).

The total NOx emissions reduction from all programs is 40.71 tons-NOx/day.

Looking into the future, the 2013 cumulative NOx emissions reduction is projected to be:

- Code-compliant residential and commercial construction is calculated to be 1,540 tons-NOx/year (8.0% of the total NOx savings);
- Savings from retrofits to Federal buildings will be 308 tons-NOx/year (1.6%);
- Savings from furnace pilot light retrofits will be 117 tons-NOx/year (0.6%);
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 2,336 tons-NOx/year (12.1%);
- Savings from SECO's Senate Bill 5 program will be 373 tons-NOx/year (1.9%);
- Electricity savings from green power purchases (wind) will be 13,065 tons-NOx/year (67.6%); and
- Savings from residential air conditioner retrofits will be 1,575 tons-NOx/year (8.2%).

The total NOx emissions reduction from all programs will be 19,314 tons-NOx/year.

Similarly, the projected 2013 OSD NOx emissions reduction is:

- Code-compliant residential and commercial construction is calculated to be 8.72 tons-NOx/day (16.1%);
- Savings from retrofits to Federal buildings will be 0.81 tons-NOx/day (1.5%);
- Savings from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.6%);
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 6.28 tons-NOx/day (11.6%);
- Savings from SECO's Senate Bill 5 program will be 1.01 tons-NOx/day (1.9%);
- Electricity savings from green power purchases (wind) will be 25.99 tons-NOx/day (48.0%); and
- Savings from residential air conditioner retrofits will be 11.03 tons-NOx/day (20.4%).

The total NOx emissions reduction from all programs will be 54.16 tons-NOx/day.

4. Technology Transfer

The Laboratory, along with the TCEQ, hosts the annual Clean Air Through Energy Efficiency (CATEE) conference, which is attended by top experts and policy makers in Texas and from around the country. At the conference, the latest educational programs and technology is presented and discussed, including efforts by the Laboratory, and others, to reduce air pollution in Texas through energy efficiency and renewable energy. These efforts have produced significant success in bringing EE/RE closer to US EPA acceptance in the Texas SIP. The Laboratory will continue to provide superior technology to the State of Texas through such efforts with the TCEQ and the US EPA.

To accelerate the transfer of technology developed as part of the TERP, the Laboratory has also made presentations at national, state and local meetings and conferences, which includes the publication of peer-reviewed papers. The Laboratory will continue to provide technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans.

These efforts have been recognized nationally by the US EPA. In 2007, the Laboratory was awarded a National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA so that these accomplishments could be rapidly disseminated to other states for their use. The benefits of CEDER include:

- Reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures;
- Continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states;
- Helping other states better identify and prioritize cost-effective clean air strategies from EE/RE; and
- Communicating the results of quantification efforts through case-studies and a clearinghouse of information.

VOLUME I – SUMMARY REPORT

Energy Efficiency/Renewable Energy Impact In The Texas Emissions Reduction Plan

Overview

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of the Texas A&M University System, is pleased to provide our ninth annual report, Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP), to the Texas Commission on Environmental Quality (TCEQ) in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002. This annual report:

- Provides an estimate of the energy savings and NOx reductions from energy code compliance in new residential construction in all ERCOT counties;
- Provides an estimate of the standardized, cumulative, integrated energy savings and NOx reductions from the TERP programs implemented by the Laboratory, SECO, the PUC and ERCOT in all ERCOT Texas;
- Describes the technology developed to enable the TCEQ to substantiate energy and emissions reduction credits from energy efficiency and renewable energy initiatives (EE/RE) to the U.S. Environmental Protection Agency (US EPA), including the development of a web-based emissions reduction calculator; and
- Outlines progress in advancing EE/RE strategies for credit in the Texas State Implementation Plan (SIP).

The report is organized in three volumes.

Volume I – Summary Report – provides an executive summary and overview;
Volume II – Technical Report – provides a detailed report of activities, methodologies and findings; and
Volume III – Technical Appendix – contains detailed data from code-compliant energy simulations for all ERCOT counties in Texas included in the analysis.

Legislative Background

The TERP was established in 2001 by the 77th Legislature through the enactment of Senate Bill 5 to:

- Ensure that Texas air meets the Federal Clean Air Act requirements (Section 707, Title 42, United States Code); and
- Reduce NOx emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE).

To achieve the clean air and emissions reduction goals of the TERP, Senate Bill 5 created a number of EE/RE programs for credit in the SIP:

- Adopts statewide Texas Building Energy Performance Standards (TBEPS) as the building energy code for all residential and commercial buildings;
- Provides that a municipality or county may request the Laboratory to determine the energy impact of proposed energy code changes;
- Provides for an annual evaluation by the Public Utility Commission of Texas (PUCT), in cooperation with the Laboratory, of the emissions reduction of energy demand, peak electric loads and the associated air contaminant reductions from utility-sponsored programs established under Senate Bill 5 and utility-sponsored programs established under the electric utility restructuring act (Section 39.905 Utilities Code);
- Establishes a 5% per year electricity reduction goal each year for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2009; and
- Requires the Laboratory to report annually to the TCEQ the energy savings (and resultant emissions reduction) from implementation of building energy codes and to identify the municipalities and counties whose codes are more or less stringent than the un-amended code.

Passed during the 78th Legislature (2003), HB 1365 and HB 3235 amended TERP to enhance its effectiveness with these additional energy efficiency initiatives:

- Requires the TCEQ to conduct outreach to non-attainment and near-non-attainment counties on the benefits of implementing energy efficiency measures as a way to meet the air quality goals under the federal Clean Air Act;
- Requires the TCEQ develop a methodology for computing emissions reduction from energy efficiency initiatives;
- Authorized a voluntary Energy-Efficient Building Program at the General Land Office (GLO), in consultation with the Laboratory, for the accreditation of buildings that exceed the state energy code requirements by 15% or more;
- Authorizes municipalities to adopt an optional, alternate energy code compliance mechanism through the use of accredited energy efficiency programs determined to be code-compliant by the Laboratory, as well as the US EPA's Energy Star New Homes program; and
- Requires the Laboratory to develop and administer a statewide training program for municipal building inspectors seeking to become code-certified inspectors for enforcement of energy codes.

Senate Bill 5 was again amended during the 79th Legislature (2005) through SB 20, HB 2481 and HB 2129. These enhanced the effectiveness of Senate Bill 5 by adding the following additional energy efficiency initiatives:

- Requires 5,880 MW of generating capacity from renewable energy technologies by 2015;
- Includes 500 MW from non-wind renewables;
- Requires the PUCT to establish a target of 10,000 megawatts of installed renewable capacity by 2025;
- Requires the TCEQ to develop methodology for computing emissions reduction from renewable energy initiatives and the associated credits;
- Requires the Laboratory to assist the TCEQ in quantifying emissions reduction credits from energy efficiency and renewable energy programs;
- Requires the Texas Environmental Research Consortium (TERC) to contract with the Laboratory to develop and annually calculate creditable emissions reduction from wind and other renewable energy resources for the state's SIP; and
- Requires the Laboratory to develop at least three alternative methods for achieving a 15 % greater potential energy savings in residential, commercial and industrial construction.

The 80th Legislature (2007), through SB 12, and HB 3693 further amended Senate Bill 5 to enhance its effectiveness by adding the following additional energy efficiency initiatives:

- Requires the Laboratory to provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC) or the International Energy Conservation Code (IECC) are equivalent to or better than the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC. The Laboratory shall make its recommendations no later than six months after publication of new editions at the end of each three-year code development cycle of the International Residential Code and the International Energy Conservation Code.
- Requires the Laboratory to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- Requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences. The form must be designed to give potential buyers information on a structure's energy performance, including: insulation; types of windows; heating and cooling equipment; water heating equipment; additional energy conserving features, if any; results of performance measurements of building tightness and forced air distribution; and an overall rating of probable energy efficiency relative to the minimum requirements of the International Energy Conservation Code or the energy efficiency chapter of the International Residential Code, as appropriate.
- Encourages the Laboratory to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reduction benefits of the home energy ratings program.
- Requires the Laboratory to include information on the benefits attained from this program in an annual report to the commission.

The 81st Legislature, 2009, extended the date of the TERP to 2019 and required the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

Laboratory Funding for the TERP

The Laboratory received $182,000 in FY 2002; $285,000 in FY 2003; $950,421 in FY 2004; $952,019 each year for FY 2005 through FY2008. In FY 2009 the Lab received $908,040 and $870,568 in FY 2010. The Laboratory has also supplemented these funds with competitively awarded Federal and State grants to provide the needed statewide training for the new mandatory energy codes and to provide technical assistance to cities and counties in helping them implement adoption of the legislated energy efficiency codes. In addition, the ESL received an award from the US EPA in the spring of 2007 to establish a Center of Excellence for the Determination of Emissions Reduction (CEDER) which has helped to enhance the EE/RE emissions calculations.

Accomplishments since January 2010

Since January 2010, the Laboratory has accomplished the following:

- Calculated energy and resultant NOx reductions from implementation of the Texas Building Energy Performance Standards (IECC/IRC codes) to new residential and commercial construction for all non-attainment and near-non-attainment counties;
- Enhanced the Laboratory's IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Enhanced the IC3 calculator, which is energy code compliance software based on the Texas Building Energy Performance Standards by adding 3-story, multi-family model in the calculator and extending the code to include Houston Amendments and 2009 IECC;
- Continued development and testing of key procedures for validating simulations of building energy performance;
- Provided energy code training workshops, including: residential, commercial IECC/IRC energy code training sessions, code-compliant software sessions throughout the State of Texas;
- Maintained and updated the Laboratory's Texas Emissions Reduction Plan (TERP) website;
- Maintained a builder's residential energy code Self-Certification Form (Ver.1.3) for use by builders outside municipalities;
- Analyzed the stringency of several residential and commercial energy codes, including the 2009 IECC, 2009 IRC and ASHRAE Standard 90.1 2007;
- Hosted the Clean Air Through Energy Efficiency (CATEE) Conference in August 2010, in Austin, Texas. Conference sessions included key talks by the TCEQ, EPA, DOE and the Laboratory about quantifying emissions reduction from EE/RE opportunities and guidance on key energy efficiency and renewable energy topics;
- Provided technical assistance to the TCEQ regarding specific issues, including:
    - Enhancement of the standardized, integrated NOx emissions reduction reporting procedures to the TCEQ for EE/RE projects;
    - Enhancement of the procedures for weather normalizing NOx emissions reduction from renewable projects;
- Enhanced the web-based emissions reduction calculator, including:
    - Continued the enhancement of the new computer architecture to allow for synchronous calculations, user accounts, and code-compliance;
- Developed 15% above code recommendations for residential buildings;
- Continued the development of verification procedures, including:
    - Worked toward the code compliance tools for commercial buildings, retail and school buildings.

Technology Transfer

To accelerate the transfer of technology developed as part of the TERP program, the Laboratory:

- Delivered "Statewide Air Emissions Calculations from Wind and Other Renewables," to the Texas Commission on Environmental Quality in August 2010.
- Updated previously developed degradation analysis to determine if degradation could be observed in the measured power from Texas wind farms.
- Updated previously developed database of other renewable projects in Texas, including: solar photovoltaic, geothermal, hydroelectric, and Landfill Gas-fired Power Plants.
- Applied previously developed estimation techniques for hourly solar radiation from limited data sets.
- Worked with the EPA and TCEQ and developed a new version of eGRID for all ERCOT counties in Texas.
- Along with the TCEQ and the US EPA, is host to the annual Clean Air Through Energy Efficiency (CATEE) Conference attended by top Texas experts and policy makers and national experts.
- Continued the National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA. The benefits of CEDER include:
    - Reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures;
    - Continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states;
    - Helping other states identify and prioritize cost-effective clean air strategies from EE/RE, and;
    - Communicating the results of quantification efforts through case-studies and a clearinghouse of information.

In addition to the tasks listed above, the Laboratory delivered presentations regarding the TERP related work, including:

- Presentation to the Clean Air Through Energy Efficiency Conference, Austin, Texas, August 2010
- Presentation to the Symposium on Improving Building Systems in Hot & Humid Climates, Austin, Texas, August 2010
- Presentation to SIMBuild, New York, New York, August 2010
- Presentation to International Conference for Enhanced Building Operations, Safat Kuwait, October 2010

Presentation of the following seven papers at the Symposium on Improving Building Systems in Hot & Humid Climates, Austin, Texas, August 2010:

- Kim, K.; Haberl, J. 2010. "Development of a Calibration Methodology for Code-compliant Simulation of a Case Study House in a Hot and Humid Climate," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Ji, J.; Baltazar, J.C.; Claridge, D. 2010. "Development of the Potential Energy Savings Estimation (PESE) Toolkit," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Do, S.; Haberl, J. 2010. "A Review of Ground Coupled Heat Pump Models Used in Whole-Building Computer Simulation Programs," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Gilman, D.; Haberl, J.; Kayati, M.; O'Neal, S. 2010. "Development of a Texas Building Registry," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Mukhopadhyay, J.; Baltazar, J.C.; Liu, Z.; Haberl, J.; Culp, C.; Yazdani, B. 2010. "A Comparative Analysis of Residential Energy Use for 2009 IECC Code Compliance and 2001 IECC Compliance with 2006 NACA Appliance Standards for Selected Climate Zones in Texas," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Kim, H.; Liu, Z.; Baltazar, J.C.; Mukhopadhyay, J.; Haberl, J., Do, S.; Culp, C.; Yazdani, B. 2010. "Energy Efficiency/Renewable Energy (RE/EE) Projects in Texas Public Schools," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas
- Alcocer, J.L.B.; Haberl, J. 2010 "Low Impact, Affordable, Low Income Houses for Mexico," *Proceedings of the 17th Symposium on Improving Building Systems in Hot and Humid Climates*, Austin, Texas

Presentation of six papers to the 2010 SimBuild Conference held in New York City, August 2010.

- Marshall, K.; Moss, M.; Malhotra, M.; Liu, Z.; Culp, C.; Haberl, J.; Herbert, C. 2010 "AIM: Web-Based, Residential Energy Calculator for Homeowners," *SimBuild 2010*, New York City, New York
- Andulson, S.; Culp, C.; Haberl, J. 2010 "EnergyPlus vs DOE-2: The Effects of Ground Coupling on Heating and Cooling Energy Consumption of a Slab-on-grad Code House in a Cold Climate," *SimBuild 2010*, New York City, New York
- Cho, S.; Haberl, J. 2010 "Integrating Solar Thermal and Photovoltaic Systems in Whole Building Energy Simulation," SimBuild 2010, New York City, New York
- Im, P.; Haberl, J. 2010 "Analysis of the Energy Savings Potential in K-5 Schools in Hot and Humid Climates: Application of High Performance Measures and Renewable Energy Systems," *SimBuild 2010*, New York City, New York
- Liu, Z.; Kim, H.; Malholtra, M.; Mukhopadhyay, J.; Baltazar, J-C.; Haberl, J.; Culp, C.; Yazdani, B.; Montgomery, C. 2010 "Going Beyond RESNET Certification for Code-Compliance Simulations: A Comparison of Detailed Results of Three RESNET-Certified, Code-Compliant Residential Simulation Programs," *SimBuild 2010*, New York City, New York
- Malhotra, M., Haberl, J. 2010 "Simulatated Building Energy Performance of Single-Family Detached Residences Designed for Off-Grid, Off-Pipe," *SimBuild 2010*, New York City, New York

Presentation of four papers at the 10th International Conference for Enhanced Building Operations, held in Safat, Kuwait, October 2010.

- Liu, J.; Baltazar, J.C.; Claridge, D. 2010 "Analysis of the Potential Savings for 14 Office Buildings with VAV Systems," *Proceedings of the 10th International Conference for Enhanced Building Operations*, Safat, Kuwait
- Baltazar, J.C.; Liu, Z.; Mukhopadhyay, J.; Marshall, K.; Gilman, D.; Lewis, C.; McKelvey, K.; Reid, V.; Haberl, J.; Culp, C.; Yazdani, B. 2010 "A Methodology for Calculating Integrated NOx Emissions Reductions from Energy Efficient and Renewable Energy (EE/RE) Programs across State Agencies in Texas," *Proceedings of the 10th International Conference for Enhanced Building Operations*, Safat, Kuwait
- Kim, S.; Haberl, J. 2010 "Application of an ASHRAE 152-2004 Duct Model for Simulating Code-Compliant 2000/2001 IECC Residences," *Proceedings of the 10th International Conference for Enhanced Building Operations*, Safat, Kuwait
- Liu, Z.; Kim, H.; Mukhopadhyay, J.; Montgomery, C.; Baltazar, J.C.; Haberl, J.; Culp, C.; Yazdani, B. 2010 "Going Beyond a Resnet Certification for Code-Compliant Simulations: A Sensitivity Analysis of Detailed Results of Three Resnet-Certified, Code-Compliant Residential Simulation Programs," *Proceedings of the 10th International Conference for Enhanced Building Operations*, Safat, Kuwait

The Laboratory has and will continue to provide leading-edge technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP. These activities were designed to more accurately calculate the creditable NOx emissions reduction from EE/RE initiatives contained in the TERP and to assist the TCEQ, local governments, and the building industry with standardized, effective implementation and reporting.

Energy and NOx Reductions from New Residential and Commercial Construction, including furnace pilot light savings and residential air conditioner retrofits

State adoption of the energy efficiency provisions of the International Residential Code (IRC) and International Energy Conservation Code (IECC) became effective September 1, 2001. The Laboratory has developed and delivered training to assist municipal inspectors to become certified energy inspectors. The Laboratory also supported code officials with guidance on interpretations as needed. This effort, based on a requirement of HB 3235, 78th Texas Legislature, supports a more uniform interpretation and application of energy codes throughout the state. In general, the State is experiencing a true market transformation from low energy efficiency products to high energy efficiency products. These include: low solar heat gain windows, higher efficiency appliances, high efficiency air conditioners and heat pumps, increased insulation, lower thermal loss ducts and in-builder participation in "above-code" code programs such as Energy Star New Homes, which previously had no state baseline and almost no participation.

In 2010 the following savings were calculated:

- In 2010, the annual electricity savings[1] from code-compliant residential and commercial construction is calculated to be 1,688,687 MWh/year (6.6% of the total electricity savings);
- Savings from furnace pilot light retrofits is 2,548,904 MBtu/year; and
- Savings from residential air conditioner retrofits[2] is 1,283,931 MWh/year (5.0%).

- In 2010, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 9,510 MWh/day (14.3%),
- Savings from furnace pilot light retrofits is 6,983 MBtu/day, and
- Savings from residential air conditioner retrofits are 9,106 MWh/day (13.7%).

- By 2013, the annual electricity savings from code-compliant residential and commercial construction is calculated to be 2,176,034 MWh/year (6.8% of the total electricity savings);
- Savings from furnace pilot light retrofits will remain at 2,548,904 MBtu/year; and
- Savings from residential air conditioner retrofits[3] will be 2,286,233 MWh/year (7.1%).

- By 2013, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 12,566 MWh/day (14.4%);
- Savings from furnace pilot light retrofits will remain at 6,983 MBtu/day; and
- Savings from residential air conditioner retrofits will be 16,216 MWh/day (18.6%).

- In 2010, the annual NOx emissions reduction[4] from code-compliant residential and commercial construction is calculated to be 1,090 tons-NOx/year (7.8% of the total NOx savings);
- Savings from furnace pilot light retrofits is 117 tons-NOx/year (0.8%); and
- Savings from residential air conditioner retrofits is 884 tons-NOx/year (5.8%).

[1] This includes the savings from 2001 through 2010.
[2] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.
[3] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.
[4] These NOx emissions reduction were calculated with the US EPA's 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

- In 2010, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 6.56 tons-NOx/day (16.1%);
- Savings from furnace pilot light retrofits is 0.32 tons-NOx/day (0.8%); and
- Savings from residential air conditioner retrofits are 6.19 tons-NOx/day (15.2%).

- By 2013, the NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,541 tons-NOx/year (8.0% of the total NOx savings);
- Savings from furnace pilot light retrofits will be 117 tons-NOx/year (0.6%); and
- Savings from residential air conditioner retrofits will be 1,574 tons-NOx/year (8.1%).

- By 2013, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 8.72 tons-NOx/day (16.1%);
- Savings from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.6 %); and
- Savings from residential air conditioner retrofits will be 11.03 tons-NOx/day (20.4%).

Integrated NOx Emissions Reductions Reporting Across State Agencies

In 2005, the Laboratory began to work with the TCEQ to develop a standardized, integrated NOx emissions reduction across state agencies implementing EE/RE programs so that the results can be evaluated consistently. As required by the legislation, the TCEQ receives the following reports:

- From the Laboratory – savings from code compliance and renewables;
- From the Laboratory, in cooperation with the Electric Reliability Council of Texas (ERCOT), the savings from electricity generated from wind power;
- From the Public Utilities Commission of Texas (PUCT) on the impacts of the utility-administered programs designed to meet the mandated energy efficiency goals of SB7 and SB5; and
- From the State Energy Conservation Office (SECO) on the impacts of energy conservation in state agencies and political subdivisions.

The total annual and OSD electricity savings for all the different programs in the integrated format was calculated using the adjustment factors for 2001 through 2020. NOx emissions reduction from the electricity and natural gas savings for the annual and OSD for all the programs in the integrated format were calculated.

In 2010 the cumulative annual electricity savings[5] is calculated as follows:

- Savings from code-compliant residential and commercial construction is 1,854,699 MWh/year (5.8% of the total electricity savings),
- Savings from retrofits to Federal buildings is 293,659 MWh/year (0.9%),
- Savings from furnace pilot light retrofits is 2,548,904 MMBtu/year (2.4%), which is equivalent to 746,822 MWh/year,
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 2,595,953 MWh/year (8.2%),
- Savings from SECO's Senate Bill 5 program is 468,611 MWh/year (1.5%),
- Electricity savings from green power purchases (wind) is 24,210,883 MWh/year (76.3%), and
- Savings from residential air conditioner retrofits is 1,560,875 MWh/year (4.9%).

The total savings from all programs is 31,731,502 MWh/year.

In 2010 the cumulative OSD electricity savings is calculated as follows:

- Savings from code-compliant residential and commercial construction is 10,641 MWh/day (12.6%),

[5] This includes the savings from 2001 through 2010.

- Savings from retrofits to Federal buildings is 805 MWh/day (1.0%),
- Savings from furnace pilot light retrofits is 6,983 MMBtu/day (2.4%), which is equivalent to 2,046 MWh/day,
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 7,113 MWh/day (8.5%),
- Savings from SECO's Senate Bill 5 program is 1,284 MWh/day (1.5%),
- Electricity savings from green power purchases (wind) are 51,190 MWh/day (60.8%), and
- Savings from residential air conditioner retrofits are 11,071 MWh/day (13.2%).

The total savings from all programs in 2010 is 84,150 MWh/day (82,104 MWh/day and 6,983 MMBtu/day), which would be a 3,506 MW average hourly load reduction during the OSD period.

By 2013, the projected cumulative annual electricity savings from all the different programs is:

- Savings from code-compliant residential and commercial construction will be 2,311,539 MWh/year (6.5% of the total electricity savings),
- Savings from retrofits to Federal buildings will be 402,732 MWh/year (1.1%),
- Savings from furnace pilot light retrofits will remain at 2,548,904 MMBtu/year (2.1%), which is equivalent to 746,822 MWh/year,
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 3,224,560 MWh/year (9.0%),
- Savings from SECO's Senate Bill 5 program will be 489,440 MWh/year (1.4%),
- Electricity savings from green power purchases (wind) will be 26,296,721 MWh/year (73.5%), and
- Savings from residential air conditioner retrofits[6] will be 2,286,233 MWh/year (6.4%).

The total cumulative annual savings from all programs will be 35,758,047 MWh/year (35,011,225 MWh/year and 2,548,904 MMBtu/year).

By 2013, the projected cumulative OSD electricity savings will be:

- Savings from code-compliant residential and commercial construction will be 13,157 MWh/day (13.4%),
- Savings from retrofits to Federal buildings will be 1,103 MWh/day (1.1%),
- Savings from furnace pilot light retrofits will remain at 6,983 MMBtu/day (2.1%), which is equivalent to 2,046 MWh/day,
- Savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 8,835 MWh/day (9.0%),
- Savings from SECO's Senate Bill 5 program will be 1,341 MWh/day (1.4%),
- Electricity savings from green power purchases (wind) will be 55,600 MWh/day (56.6%), and
- Savings from residential air conditioner retrofits will be 16,216 MWh/day (16.5%).

The total cumulative OSD savings from all programs will be 98,298 MWh/day (96,252 MWh/day and 6,983 MMBtu/day), which would be a 4,096 MW average hourly load reduction during the OSD period.

In 2010 the cumulative annual NOx emissions reduction[7] from all the different programs is:

- Reduction from code-compliant residential and commercial construction is 1,303 tons-NOx/year (6.9% of the total NOx savings),
- Reduction from retrofits to Federal buildings is 225 tons-NOx/year (1.2%),
- Reduction from furnace pilot light retrofits is 117 tons-NOx/year (0.6%),
- Reduction from the PUC's Senate Bill 5 and Senate Bill 7 programs is 1,783 tons-NOx/year (9.4%),
- Reduction from SECO's Senate Bill 5 program is 357 tons-NOx/year (1.9%),
- Reduction from green power purchases (wind) is 14,047 tons-NOx/year (74.3%), and
- Reduction from residential air conditioner retrofits is 1,075 tons-NOx/year (5.7%).

The total cumulative annual NOx emissions reduction from all programs is 18,907 tons-NOx/year.

In 2010, the cumulative OSD NOx emissions reduction from all the different programs is:

- Reduction from code-compliant residential and commercial construction is 7.34 tons-NOx/day (14.2%),
- Reduction from retrofits to Federal buildings is 0.59 tons-NOx/day (1.1%),
- Reduction from furnace pilot light retrofits is 0.32 tons-NOx/day (0.6%),

[6] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

[7] These NOx emissions reductions were calculated with the US EPA's 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

- Reduction from the PUC's Senate Bill 5 and Senate Bill 7 programs is 4.79 tons-NOx/day (9.3%),
- Reduction from SECO's Senate Bill 5 program is 0.97 tons-NOx/day (1.9%),
- Reduction from green power purchases (wind) are 30.04 tons-NOx/day (58.2%), and
- Reduction from residential air conditioner retrofits are 7.53 tons-NOx/day (14.6%).

The total cumulative OSD NOx emissions reduction from all programs is 51.58 tons-NOx/day.

By 2013, the projected cumulative annual NOx emissions reduction from all the different programs will be:

- Reduction from code-compliant residential and commercial construction will be 1,620 tons-NOx/year (7.6% of the total NOx savings),
- Reduction from retrofits to Federal buildings will be 308 tons-NOx/year (1.4%),
- Reduction from furnace pilot light retrofits will be 117 tons-NOx/year (0.5%),
- Reduction from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 2,147 tons-NOx/year (10.0%),
- Reduction from SECO's Senate Bill 5 program will be 373 tons-NOx/year (1.7%),
- Reduction from green power purchases (wind) will be 15,257 tons-NOx/year (71.3%), and
- Reduction from residential air conditioner retrofits will be 1,574 tons-NOx/year (7.4%).

The total cumulative annual NOx emissions reduction from all programs will be 21,396 tons-NOx/year.

By 2013, the projected cumulative OSD NOx emissions reduction from all the different programs will be:

- Reduction from code-compliant residential and commercial construction will be 9.03 tons-NOx/day (14.9%),
- Reduction from retrofits to Federal buildings will be 0.81 tons-NOx/day (1.3%),
- Reduction from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.5%),
- Reduction from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 5.78 tons-NOx/day (9.5%),
- Reduction from SECO's Senate Bill 5 program will be 1.01 tons-NOx/day (1.7%),
- Reduction from green power purchases (wind) will be 32.63 tons-NOx/day (53.8%), and
- Reduction from residential air conditioner retrofits will be 11.03 tons-NOx/day (18.2%).

The total cumulative OSD NOx emissions reduction from all programs is projected to be 60.61 tons-NOx/day.

Figure 2 shows the NOx emissions reduction through 2020 for the electricity and natural gas savings from all TERP programs reporting to the TCEQ. Table 1 provides the details regarding the annual degradation, transmission and distribution losses, discount factors and growth factors that were used in the analysis[8]. Additional details of the analysis are reported in Volume III of this report.

Table 1: Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs

	ESL-Single Family[16]	ESL-Multifamily[16]	ESL-Commercial[16]	Federal Buildings[15]	Furnace Pilot Light Program[15]	PUC (SB7)[15]	PUC (SB5 Grant Program)[15]	SECO[15]	Wind-ERCOT[8]	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor[11]	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	5.00%	5.00%
T&D Loss[9]	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%
Initial Discount Factor[12]	20.00%	20.00%	20.00%	20.00%	20.00%	25.00%	25.00%	60.00%	25.00%	20.00%	20.00%
Growth Factor	3.25%	1.54%	3.25%	0.00%	0.00%	0.00%	0.00%	0.00%	Actual Rates	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes

[8] These factors were determined by TCEQ.

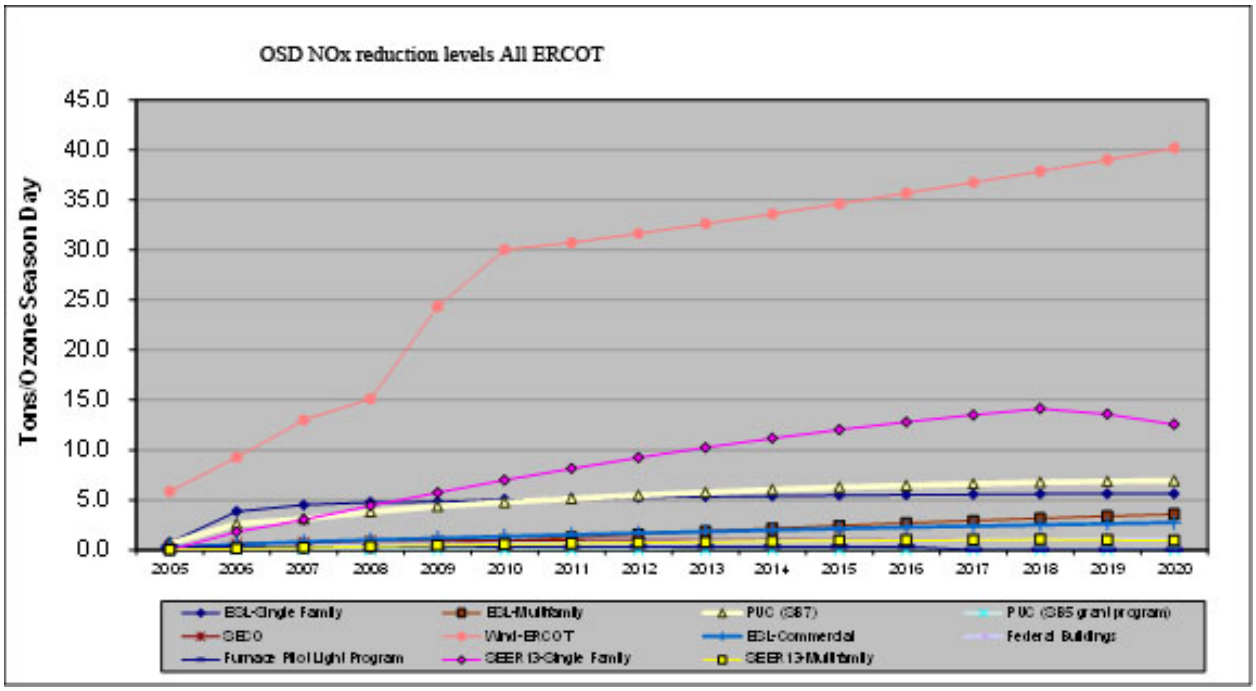

Figure 2: Cumulative OSD NOx Emissions Reduction Projected through 2020

Technology for Calculating and Verifying Emissions Reduction from Energy Used in Buildings

In 2004 and 2005, the Laboratory developed a web-based Emissions Reduction Calculator, known as "*eCalc*," which contains the underlying technology for determining NOx emissions reduction from power plants that generate the electricity for the user[9]. The emissions reduction calculator is being used to calculate emissions reduction for consideration for SIP credits from energy efficiency and renewable energy programs in the TERP.

In 2007, the Laboratory enhanced the calculator to provide additional functions and usability, including:

- Renaming the product IC3 v2.0
- Enhanced the Laboratory's IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Enhanced web-based emissions calculator, including:
    - Use of the calculator to determine 15% above code residential and commercial options.
    - Gathered, cleaned and posted weather data archive for 17 NOAA stations;
    - Performed comparative testing of the calculator vs. other, non-web-based simulation programs;
    - Developed and tested radiant barrier simulation;
    - Using the web-based emissions calculator, started development of the derivative version Texas Climate Vision calculator for the City of Austin;
- Continued the development of verification procedures, including:
    - Completed the calibrated simulation of a high-efficiency office building in Austin, Texas;
    - Continued work to develop a calibrated simulation of an office building in College Station; and
    - Continued work to develop a calibrated simulation of a K-12 school in College Station;

In 2008, work on both web based calculators continued;

- Deployed IC3 v3.2 to handle a wider selection of single family building configurations (http://ic3.tamu.edu);
- Delivered TCV v1.0 to the City of Austin for their testing;
- Continued to operate the original eCalc;

[9] eCalc reports NOx, SOx and CO2 emissions reduction from the US EPA eGRID database for power providers in the ERCOT region.

- Supported modeling efforts by building enhanced tools for batch simulation;
- Provided training on both IC3 and TCV.

In 2009, IC3 developments included:

- A sister product, AIM was created for the State Comptroller's office.
- Usage statistics continue to climb.
- Updated to v3.6 which included 3 story houses, external cladding, more sophisticated ceiling/roof models, enhanced foundation modeling and the ability to copy projects

In 2010 there were several software updates including:

- IC3
  - 3.9.0 – Slab Insulation Support
  - 3.7.0 – 3.8.0 First Version of Multifamily Released along with numerous tweaks and fixes
  - 3.6.2 – New Building Model Integrated, Updated Artwork and Illustrations
- DDP
  - 1.7.05 – Added Heat Reject Recording for Electric and Gas
- Web Reports and Texas Building Registry
  - Registry 0.x – First versions of the Web Reports on TCV, eCalc, and IC3
  - Registry 1.0 – City and County Reports
  - Registry 1.1 – Cross-linked Reports for City and County
  - IC3 Reports 1.0 – Updated Certificate Reports which replace Registry 1.1 and evolve into the Texas Building Registry

Figure 3: AIM Score Page

Planned Focus for 2011

In FY 2009, the Energy Systems Laboratory will continue in its cooperative efforts with the TCEQ, PUCT, SECO, US EPA and others to ensure EE/RE measures remain a cost-effective solution to clean air, and continue to support the energy efficiency and renewable energy opportunities of the TERP. The Laboratory team will:

- Continue to assist the TCEQ to obtain SIP credits from energy efficiency and renewable energy using the Laboratory's Emissions Reduction Calculator technology;
- Continue to verify, document and report energy efficiency and renewable energy savings in all TERP EE/RE programs for the SIP in each non-attainment and affected county using the TCEQ/US EPA approved technology;
- Continue to assist the PUCT with determining emissions reductions credits from energy efficiency programs funded by SB 7 and SB 5;
- Assist political subdivisions and Councils of Governments with calculating emissions reductions from local code changes and voluntary EE/RE programs for SIP inclusion;
- Continue to refine the cost-effective techniques to implement 15% above code (2009 IECC) energy efficiency in low-priced and moderately-priced residential housing;
- Continue to refine the cost-effective methods and techniques to implement 15% above code energy efficiency in low-priced and moderately-priced commercial buildings;
- Continue to develop creditable procedures for calculating NOx emissions reductions from green renewable technologies, including wind power, solar energy and geothermal energy systems;
- Continue development of well-documented, integrated NOx emissions reductions methodologies for calculating and reporting NOx reductions, including a unified database framework for required reporting to TCEQ of potentially creditable measures from the ESL, PUCT, and SECO SB 5 initiatives;
- Upon request, provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC), or the International Energy Conservation Code (IECC), are equivalent to, or better than, the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC. This will consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- Develop and maintain a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences.
- Continue to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reductions benefits of the home energy ratings program.
- Include all benefits attained from this program in an annual report to the commission.
- Enhance IC3 to support multifamily residences, and add other features to enhance adoption.
- Engage production builders and municipalities in overcoming obstacles to their using IC3 for their new home construction.
- Seek funding to enhance TCV (Austin's version of IC3).
- Update ESL and TERP (SB5) websites as needed.

The Laboratory has and will continue to provide leading-edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP.

If any questions arise, please contact us by phone at 979-845-1280, or by email at terpinfo@tees.tamus.edu.